Prototyping Automation and Dynamic Observing with the AuScope Array

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Abstract The continuous observing mode envisioned for the new array of VGOS stations would benefit greatly from a high level of automation, from scheduling through to analysis. The centrally-operated AuScope VLBI array of three 12-m antennas in Australia is serving as a testbed for these automation techniques. Here we describe the challenges we are addressing and how we are using simulations to understand where the most beneficial improvements can be obtained (in dynamic scheduling for example), and we present the progress we have already made.

Keywords VLBI, VGOS, observations, techniques

1 Introduction

The AuScope Very Long Baseline Interferometry (VLBI) array, consisting of three 12-m diameter radio telescopes at Yarragadee (WA), Katherine (NT), and Hobart (TAS), is an important southern component of the global IVS network [1]. The array was constructed as part of the Australian Federal Government's National Cooperative Research Infrastructure Strategy (NCRIS), funded in 2006, and is a component of AuScope, an infrastructure framework to support geological, geochemical, geophysical, and geospatial research. The VLBI array is currently participating in $\sim$ 140 IVS 24-hour sessions per year but has demonstrated sustained operations at a level of 210 days per year over a 12-month period in 2014/15. The increased number of stations and observations in the southern hemisphere that AuScope provides has significantly addressed the north-south imbalance in global geodetic solutions [2]. Being a self-contained VLBI array with centralized operations and a scheduling, correlation, and analysis capability, it also serves as a useful facility for testing new technologies and techniques.

The main focus in geodetic VLBI at the moment is the transition to VGOS, the VLBI Global Observing System [3]. The VGOS vision includes a global array of small, fast slewing antennas with broadband receiving systems and high data recording rates. The array would operate continuously, and initial data products are required within 24 hours of observing. It has been suggested that VGOS would benefit greatly from a centralized operations model where a handful of Operations Centers (OCs) manage the scheduling, observing, correlation, and analysis for the entire array (e.g., [4]).

Centralized operations of the VGOS array would provide the opportunity to make the best use of the available resources of antennas and correlators. Remote control and monitoring of these facilities would allow observing programs to be optimized to best meet their aims, and these decisions could be made in real time if necessary rather than months in advance as is typical in the current paradigm. This concept has been termed Dynamic Observing [4]. For example, rapid dUT1 observations could be configured with two antennas with the best long east-west baseline and an idle small correlator with good network connectivity. Meanwhile an experiment to determine Earth Orientation Parameters could be configured with an array with a well-balanced geometry. Before a 24-hour session is started, a short observation could be made to check for fringes and measure telescope sensitivity (SEFD). This

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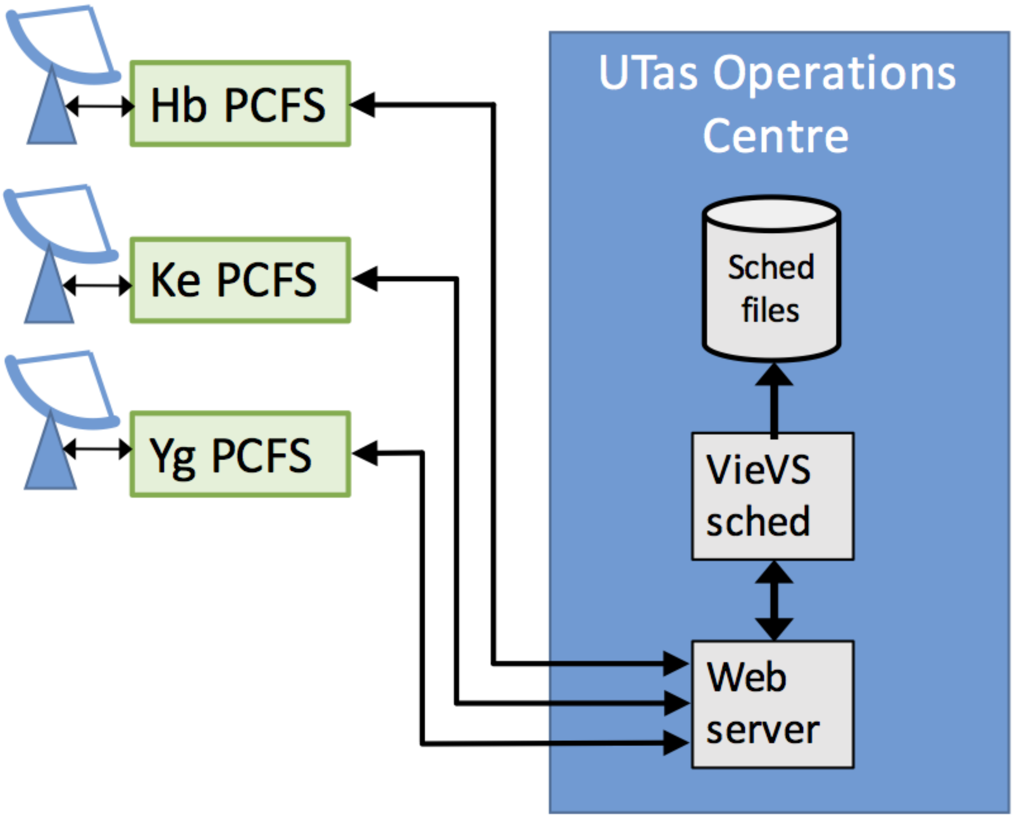

Fig. 1 A schematic showing the main components of the Dynamic Observing test made with the AuScope array in March 2016. Scheduling was handled from UTas with a 15-minute refresh cycle, and observatories were able to communicate with the operations center to report their availability and retrieve schedules.

information could be used to generate a schedule that is optimized for current telescope performance.

A significant problem with the Dynamic Observing concept is that, for reasons such as security, many facilities will not permit remote access or control. In this paper we describe a possible solution to this problem and present a demonstration of its implementation using the AuScope array.

2 A Demonstration of Secure Dynamic Observing

A facility could still take part in Dynamic Observing if it maintained full control over participation in operations and could join or leave the pool of resources at any time. However, under this scenario it would be necessary for the Operations Center to respond quickly to these changes and adapt the observing program accordingly. In turn, the remote facility (telescope or correlator) would be required to send the Operations Center the necessary status information and, in the case of an observatory, regularly obtain and execute schedule information.

In March 2016 we began work to test the feasibility of this solution using the AuScope VLBI array where scheduling of the observations was coordinated from the operations room at the University of Tasmania. At this stage, no attempt at correlator operation was made. All three 12-m telescopes were used with monitoring and automated scheduling carried out from the operations room. The telescopes were configured with a 1-Gbps observing mode (S/X-band, 16-MHz bands, and 2-bit sampling).

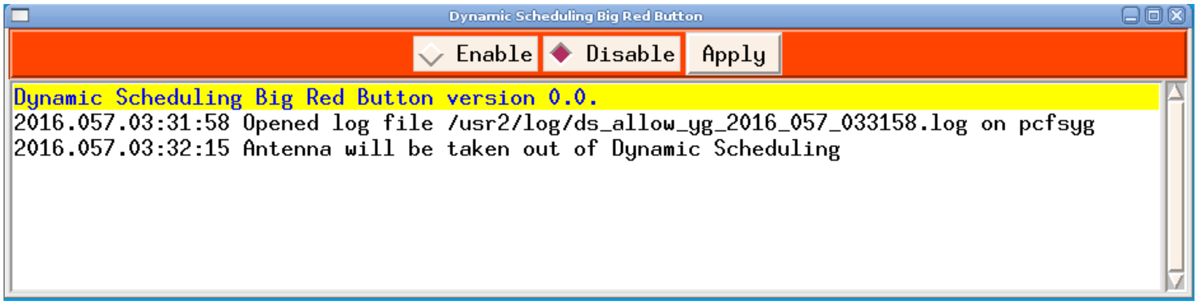

Fig. 2 The user interface running at Katherine that permits the observatory to opt in or out of Dynamic Observing sessions at any time.

At the operations center a version of the VieVS scheduler `vie_sched` (running under Octave) was used [5]. This software was configured to generate a new piece of schedule every 15 minutes based on information on telescope availability: a schedule was only generated for an observatory if it reported that it could participate. A 15-minute cycle time was chosen as this is the minimum amount of time that a tropospheric solution could be obtained under the observing mode in use. Once a new schedule file was generated, the information on the scheduled telescopes, the schedule file name, and the start time were all published on a Web server. At 0 UT every day, the scheduling software produced a VEX file of the past 24 hours of observations ready for correlation (Figure 1).

At the observatories, the standard PC Field System (PCFS) software was used but with three additions. The first was a simple application with a graphical interface that allows a local user to join or leave the observations at any time. The user can simply choose to participate or not, and this status information is sent immediately to the operations center (Figure 2). The second piece of software is called `dysched.pl`, a script that runs on a continuous one minute cycle. It uses an additional PCFS program called `mondump` to send status information to the schedule server, retrieve a new schedule if one is available, and append it to the dynamic observing schedule that is currently running. If the observatory has chosen not to participate in an observation, `dysched.pl` will not update the schedule but will continue to run and reactivate the observations when the local user chooses to do so. The monitoring information, including the antenna availability status, is received at the Operations Center and displayed on a Web page.

The demonstration session lasted for approximately eight hours. During this time, antennas were locally added and removed, and it was confirmed that the scheduling software adapted accordingly. Following the observations, the data from Katherine and Yarragadee were shipped to Hobart for correlation on a local PC cluster using DiFX. Good fringe detections were obtained on all baselines.

The scheduling software keeps a record of the last source observed in the previous 15-minute segment, the antenna position, and cable wrap information. This is used as a starting point for the following 15 minutes. This (currently) has the disadvantage that an optimization of source and sky coverage over a longer period (24 hours in the case of current IVS observations) is not done. It will be necessary to compare the quality of results from these two observing modes and assess if a 15-minute cycle is suitable or not. If not, then longer cycle times may be needed, or changes to how the scheduling software uses previous observations to optimize for future ones may be required.

3 Conclusions and Outlook

The AuScope VLBI array has been used to make some preliminary demonstrations of the Dynamic Observing concept while allowing local stations to maintain control and, thereby, hopefully alleviating restrictions that might prevent centralized coordination of operations in a VGOS scenario.

We plan to continue developing and demonstrating the Dynamic Observing concept, firstly by increasing the duration of experiments to 24 hours and making comparisons of data products with those from the traditional 24-hour block concept. We will investigate whether the 15-minute cycle time is optimal and if there is a benefit in making this a dynamic quantity that changes depending on telescope parameters and data rates. Other developments will include adding a correlator feedback loop for fringe checking and antenna sensitivity measurements which can be used by `vie_sched` for optimization. Further, we will include telescopes from other institutes to further test and demonstrate the capabilities of Dynamic Observing. Routine application of Dynamic Observing could lead to a significant increase in observing time. Whenever an IVS network station finds itself idle for a few hours (e.g., an astronomy session was cancelled due to bad weather) and is willing to observe, it can be easily included in global observations.

A further aim is to move from development to implementation, making Dynamic Observing the routine procedure for the AuScope VLBI array.

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